I. INTRODUCTION

The research described here was performed by DRI/McGraw-Hill for Southwestern Bell. The purpose of the research is to assess the consequences of adopting the Stipulation and Agreement (Stipulation) filed by Southwestern Bell and other parties on May 3, 1993, and to provide policy makers insight into the past and future significance of telecommunications network modernization to the economic well-being of the state of Arkansas.

In **Section II** of the report, we discuss the relationship between telecommunications infrastructure modernization and historical trends in U.S. productivity growth and find that the telecommunications network has indeed been a vital input into the nation's economic performance.

In **Section III**, we analyze the contribution of telecommunications to the economic performance of Arkansas over the 1977-1991 period. Earlier studies by DRI have demonstrated that telecommunications benefits the U.S. economy through the more efficient production of telecommunications, and through the increased use of telecommunications in place of more costly, less efficient means of production.[1] In this section of the report, we quantify the effects of more efficient telecommunications production and increased telecommunications usage on jobs, personal income, and tax revenues in Arkansas over the 1977 to 1991 interval.

Section IV of this report presents an analysis of the implications for the Arkansas economy of Southwestern Bell's future telecommunications network modernization plans under the Stipulation and under an alternative in which the Stipulation does not occur.

In **Section V**, we detail the extent to which telecommunications advances have influenced two important issues that are part of Arkansas' public policy agenda, namely health care and education cost containment. In **Section VI** of this report we examine the effects of telecommunications on subgroups of Arkansas' population: low-income residents (the lowest 20% ranked by income per household), high-income residents (the highest 20% ranked by income per household), and the elderly (over 65).

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[1] For a further discussion of the relationship between telecommunications efficiency and productivity gains, refer to:

Francis J. Cronin, et al. "Factor Prices, Factor Substitution and the Relative Demand for Telecommunications Across U.S. Industries"; *Information Economics and Policy (1993, No. 5)*

_____. "Telecommunications Technology, Sectoral Prices, and International Competitiveness". *Telecommunications Policy (September/October 1992)*

_____, "Linking Telecommunications and Economic Competitiveness", *Telephony (7 September 1992)*

_____. "Telecommunications Infrastructure and Economic Growth: An Analysis of Causality". *Telecommunications Policy (December 1991)*

_____, "Telecommunications Infrastructure Investment and Economic Development", *Telecommunications Policy (August 1993)*

Finally, in **Section VII** of the report we present the methodology and assumptions used in our analysis of the relationship between telecommunications network infrastructure enhancements and the economic performance of the state of Arkansas. More detailed methodological notes can also be found in DRI/McGraw-Hill's report, The Contribution of Telecommunications Infrastructure to Aggregate and Sectoral Efficiency.[2]

A summary of the findings is highlighted below:

Telecommunications investment, productivity and economic growth

- Economic growth can result from either increasing the use of inputs or an improvement in total factor productivity, or a combination of the two. Productivity growth, therefore, is a fundamental factor in determining a nation's standard of living.

- Over the hundred year period, 1889 to 1988, the rate of total factor productivity growth in the U.S. averaged 1.6% per year, accounting for 50% of the average annual increase in real Gross Domestic Product (GDP). Since the early 1960s, the growth of productivity for the U.S. economy has fallen below our historical performance and the contemporaneous performance of other industrialized nations. Researchers now estimate that this deterioration in our productivity trends has lowered the standard of living by as much as 40%.

- Increased investment in publicly owned infrastructure can be used to stimulate the economy. In addition, privately owned network providers can stimulate the economy through modernization of their infrastructures.

- Public infrastructure investment experienced virtually no real growth over the 1964-1991 period. Over the same period, telecommunications and gross private investment showed significant real growth. Telecommunications investment growth has generally been about 69% higher than gross private investment growth.

- The telecommunications industry has outpaced the total economy in productivity growth. In fact, the telecommunications industry increased the productivity of its production process by an average of 3.0% per year between 1963 and 1991.

Telecommunications Infrastructure & Competitiveness

- Between 1963 and 1991, the price of telecommunications services fell 61% relative to the GNP price deflator and 64% relative to the average wage rate.

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2 Francis J. Cronin, et. al., *The Contribution of Telecommunications Infrastructure to Aggregate and Sectoral Efficiency*, DRI/McGraw-Hill, February 1991.

- The U.S. economy as a whole increased its use of telecommunications as a percentage of output at a rate of 3.9% per year over the 1965-1987 interval. This is 28% higher than the next highest industry.

- The combined impacts of improved production efficiencies by the telecommunications sector and increased telecommunications consumption by other sectors saved the U.S. 1991 economy $102.9 billion in labor and capital.

- In 1982, the Consumer Price Index (CPI) was five percentage points lower as a result of the productive impacts induced by the activity within the telecommunications sector

- Between 1977 and 1982, U.S. exports increased by over $50 billion as a result of increased competitiveness induced by telecommunications infrastructure improvements.

- The resource savings due to telecommunications investment has positively affected both economy-wide prices and international competitiveness and provided society with a high rate of "social" return.

- Telecommunications can play an important role in information dissemination by providing rural communities with access to more extensive urban library systems.

- Advancements in telecommunications technology since 1963 have contributed to savings in health care expenses. Potential applications of existing telecommunications technology could save the U.S. economy $24 billion (current dollars) in 1995 and $38 billion by the year 2000.

- Annual education costs in 1991 would have been $8.4 billion higher had the technology of telecommunications service provision not advanced since 1963.

Historical Telecommunications Network Modernization and the Arkansas Economy

- Over the 1977-1991 time period, efficiency gains resulting from telecommunications infrastructure modernization and increased usage since 1977 generated, on average, almost 4,800 jobs per year in the Arkansas state economy.

- The productivity enhancements associated with telecommunications infrastructure modernization generated a cumulative total of $361 million in nominal personal income between 1977 and 1991 (an average of about $26 million per year), as well as $32.9 million in state and local tax revenue between 1977 and 1991.

- The CPI was 1.4% lower as a result of telecommunications-induced efficiency gains, indicating that a dollar bought more goods and services in Arkansas in 1991 than it could have without post-1977 infrastructure modernization.

- On average, from 1977 to 1991, the average Arkansas household experienced the equivalent of an additional $144 in income per year due to the telecommunications advances since 1977 (in 1991 dollars).

- Arkansas's economy would have shed an additional 2,300 jobs during the 1980-82 recession had telecommunications not advanced from 1977 technology.

Future Telecommunications Network Modernization and the Arkansas Economy

- The future benefits of network modernization to the Arkansas economy can be segmented into two effects. The first effect focuses on the contribution of network construction activities to the Arkansas economy. The second effect relates to the impact of telecommunications usage on the Arkansas economy.

- In the Accelerated Deployment scenario, where the Stipulation is adopted, additional investment is made to modernize the network, and rates for certain services decline, an additional 9,400 person-years of employment are generated compared with the Limited Deployment scenario over the 1993 to 2002 period. These additional jobs will translate into $480 million in additional personal income for Arkansas residents, and $46 million in state and local tax revenues through 2002.

- In the Limited Deployment scenario where the Stipulation is not adopted and the revenue requirement effect of this additional investment is returned to the rate payer, overall telecommunications usage is less than in the Accelerated Deployment scenario. In this scenario, the efficiency induced by telecommunications usage will allow employment to expand by 24,000 person-years over the 1993 to 2002 period. As a result, both personal income and state and local tax revenues will also be higher.

- Returning the revenue requirement of the Company's additional investment to the rate payer would generate approximately 3,200 person-years of employment over the 1993 to 2000 period. Most of these jobs will be in the personal service and retail trade sectors as these sectors are primarily driven by Arkansas disposable income. This is less than the "construction effect" associated with the Accelerated Deployment scenario which generated 4,000 person-years of employment.

Telecommunications Investment and Health Care and Education

- Assuming telecommunications reduced education costs in Arkansas in the same proportion as cost reductions to total U.S. education, advances in telecommunications production and consumption reduced 1991 Arkansas education costs by about $33.3 million. The cumulative savings enjoyed by the Arkansas economy over the entire 1977 to 1991 interval totaled $238.6 million in 1991 dollars.

- Assuming telecommunications reduced health care costs in Arkansas in the same proportion as cost reductions to total U.S. health care, advances in telecommunications

production and consumption reduced 1991 Arkansas health care costs by about $32.8 million. The cumulative savings enjoyed by the Arkansas economy over the entire 1977 to 1991 interval totaled $233.1 million in 1991 dollars.

Telecommunications Investment and Specific Stakeholder Groups

- Telecommunications services have the potential to improve the lives of Arkansas' elderly, low-income, and high-income residents through (1) increased access to services and, (2) lower prices.

- The purchasing power of the average household in Arkansas was 1.3% higher in 1991 than it would have been were it not for improvements in telecommunications since 1977.

- The wealthiest 20% of the population has enjoyed the greatest increase in spending power as a result of telecommunications advances. We estimate that the typical high income household would have had to have spent an additional $576 to purchase the same goods and services as it had in 1991.

- Telecommunications-induced efficiency gains increased the spending power of low income households by 1.1% in 1991, or $114.

- Elderly households may potentially lag behind the average household in terms of benefits accrued due to increased telecommunications efficiency because elderly households consume proportionately fewer telecommunications-intensive applications than the average household. Telecommunications-induced efficiency gains increased the spending power of the elderly by 1.1% in 1991, or $154.

II. TELECOMMUNICATIONS MODERNIZATION AND THE NATIONAL ECONOMY

II-1. TELECOMMUNICATIONS INVESTMENT, PRODUCTIVITY, AND ECONOMIC GROWTH

Introduction

This chapter provides insights into the relationship between productivity growth and telecommunications as well as the role that telecommunications can play in economic growth at the national level.[3]

Productivity Trends

> *"Productivity growth...is the single most important determinant of a nation's standard of living, the consistent improvement of which is a fundamental concern of sound economic and social policy."*[4] *[National Telecommunications and Information Administration, 1991]*

Economists have long recognized a close relationship between productivity (the rate at which an economy transforms productive inputs into output) and economic growth. By improving productive efficiency (i.e., reducing the consumption or cost of inputs necessary to produce a given level of output), an economy can sustain increased output, price stability, and a rising standard of living. Since World War II, special efforts in the discipline of economics have been devoted to defining and measuring productivity, the factors affecting it, and its rate of change.

Central to this discussion is the efficiency with which inputs (e.g., labor, capital, materials, energy, etc.) are combined in the production process--or, what economists call total factor productivity (TFP). The term "total factor productivity growth" is defined as changes in final output per unit of combined labor, capital, and materials inputs.[5] Growth in total factor productivity implies that a given level of output can be produced with a smaller quantity of inputs or that a given amount of inputs can produce a greater quantity of output. Either way, improvements in TFP make the economy better off.

For decades, the U.S. economy has been plagued by persistently low rates of productivity growth. *Since the 1960s, the growth of productivity for the U.S. economy has fallen below our historical performance and the contemporaneous performance of other industrialized*

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3 For this analysis, time intervals have been selected to maximize use of reliable data. Whenever feasible within the context of this study, analyses have been updated to reflect the most recent data.

4 *The NTIA Infrastructure Report: Telecommunications in the Age of Information.* Washington, DC: U.S. Department of Commerce, October, 1991, page C2.

5 Bureau of Labor Statistics Multifactor Productivity Indexes, Explanatory Note. Documentation from US Dept. of Commerce, Bureau of Labor Statistics.

nations. In fact, since the mid-1970s the U.S. economy has experienced almost no growth in aggregate productivity. *Low or stagnant rates of productivity growth imply that actual output growth is constrained to that which can be achieved by increasing inputs, not by improved efficiencies in their use.*

From 1889 to 1988 period, the rate of total factor productivity growth in the U.S. averaged 1.6% per year[6]--accounting for 50% of the average annual increase in real Gross Domestic Product (GDP). In fact, between 1948 and 1966, total factor productivity growth averaged 2.4% and accounted for 66% of the gain in real GDP. During the 1970s, U.S. productivity growth fell substantially behind historical rates. For the decade 1973-82, productivity levels in the U.S. actually declined. U.S. productivity growth improved following the 1981-82 recession, but continued to trail its historical average. While the U.S. remains ahead of Japan and Germany in productivity levels for both the economy as a whole and specific industries (e.g., scientific instruments non-electrical machinery),[7] productivity growth rates lag behind these important competitors.

With total factor productivity growth below long-term historical norms, the U.S. has experienced a relative stagnation in the growth of real income per employee. The increase in the proportion of two-earner households is, in part, an attempt on the part of U.S. households to maintain their standard of living.

As shown in ***Table II-1-1***, much of the recent improvement in U.S. productivity growth has been in the manufacturing sector, while the non-manufacturing sectors, including construction, finance and insurance, personal services, and wholesale and retail trade, have continued to be weak.[8] Furthermore, ongoing research by DRI/McGraw-Hill indicates that a large proportion of the increase in manufacturing productivity is based on government statistical quality adjustments to the computer industry, which actually reflect increases in processing power.[9]

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6 John W. Kendrick, "U.S. Productivity Performance in Perspective," *Business Economics*, October 1991, page 7.

7 "America the super-fit", *The Economist*, February 13, 1993, page 67.

8 Non manufacturing productivity figures can be derived through inference by observing that manufacturing productivity figures--a component of private business figures--are higher than the total. Hence, the non manufacturing sectors which include construction, finance and insurance, personal services, and wholesale and retail trade, have lower productivity values.

9 F.J. Cronin, et al., "The Productivity of the Information Technology Sectors in the American Economy," work in progress, DRI/McGraw-Hill.

Table II-1-1
Trends in U.S. Productivity and
Gross Domestic Product (GDP) Growth

	Compound Annual Growth (%)		
	1960-73	1973-82	1982-90
Total Factor Productivity			
Private Non-Farm	1.6	-0.5	1.2
Manufacturing	2.5	-0.1	3.8
Real GDP ($1987)	4.0	1.6	3.3
Real GDP per Employee	1.2	-0.2	0.7

Sources: TFP Figures are available from the Bureau of Labor Statistics. GDP figures are available from the National Income and Product Accounts, "National Product and Income," Table 1.2.

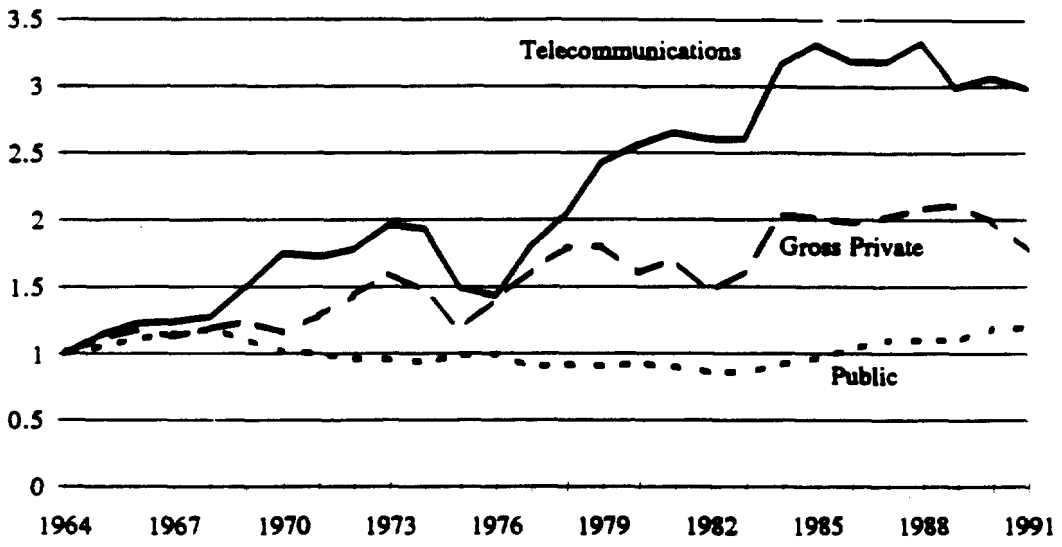
Investment Trends

Traditionally, economists have examined capital and labor as the underlying drivers of growth. More recently, this analysis has been extended to account for improvements in the "quality" of capital and labor inputs as a result of such factors as R&D and education. In the 1980s, economists further expanded their concept of inputs to include public infrastructure. Public infrastructure, such as transportation systems, were recognized as pervasive networks with substantial implications for the productivity of the nation. In the past few years, the concept of productive infrastructure has itself been expanded to encompass "public" networks owned, operated, and maintained by "private" companies, including telecommunications.

Exhibit II-1-1, below, compares trends in telecommunications infrastructure investment, gross private investment, and public infrastructure investment, from 1963 to 1991, indexed to 1964, and measured in real 1991 dollars. This exhibit demonstrates that public infrastructure investment experienced virtually no real growth in the 1963-1991 interval. In fact, when measured *relative to GNP*, public infrastructure investment is found to have declined by 42%. Over the same time period telecommunications and gross private investment have shown significant real growth, with telecommunications investment growing over three times, and gross private investment over two times their 1964 levels. Telecommunications investment grew to nearly three times its 1964 level; gross private investment grew to nearly two times its 1964 level. Telecommunications investment growth has generally been about 69% greater than gross private investment growth.

Exhibit II-1-1

Telecommunications Infrastructure, Gross Private, and Public Infrastructure Investment (Index, 1964=1.0)



Telecommunications infrastructure investment is defined as common carrier and domestic equipment investment. Public infrastructure investment is defined as total federal, state, and local expenditures for new public construction.

In fact, the period from 1963 to 1985 was characterized by heavy investment in expanding and modernizing the U.S. telecommunications infrastructure (***Exhibit II-1-1***). The telephone companies deployed technological innovations that led to major new network capabilities including: 1) computer-controlled switching systems, 2) touch-tone signaling, 3) replacement of electro-mechanical switching by analog electronic switching, and analog by digital switching, 4) the extensive deployment of common channel signaling in the nation's long-distance network, and 5) "digital" transmission facilities and satellite communications.

Telecommunications Productivity

Driven by these investments, the telecommunications industry has increased its productive efficiency. ***Table II-1-2*** shows that between 1963 and 1991, the total factor productivity of the telecommunications industry climbed 3.0% per year. *Almost as remarkable was the steadiness with which the telecommunications industry improved its productivity--it was one of a small set of industries generating substantial resource savings through the late 1970s, when most of the economy lapsed into productivity losses.* It was also the only industry during the 1963 to 1991 period to lower its requirements in all three input categories (labor, capital, and materials). Although much of telecommunications-induced productivity gains are manifested in reduced labor requirements, the telecommunications

industry also increased the efficiency with which it used both capital and materials. As a result of improvements in telecommunications *production* efficiencies between 1963 and 1991, DRI estimates that the nation's economy saved $60.1 billion in total resources in 1991. In fact, telecommunications had the greatest improvement in its usage of capital and labor of any industry.

Table II-1-2

Leontief Index of Direct Productivity Gains
(1963 through 1991, in 1991 dollars)

	Total	Capital	Labor	Materials
Telecommunications	3.0	0.4	2.3	0.3
Instruments	2.4	-0.1	2.1	0.4
Comp. Office & Non-Elec. Mach.	2.4	0.0	2.0	0.4
Electric & Electronic Equipment	2.2	0.0	2.0	0.3
Textiles	1.0	0.0	0.8	0.3
Chemicals and Products	1.0	0.0	0.7	0.3
Rubber & Plastics	1.0	0.0	0.8	0.2
Furniture	0.8	0.0	0.6	0.2
Business Services	0.5	0.0	0.1	0.4
Paper and Paperboard	0.5	-0.1	0.6	-0.1
Agric. Food & Tobacco.	0.5	0.0	0.3	0.2
Fabricated Metals	0.4	-0.1	0.4	0.1
Motor Vehicle. & Misc.	0.4	0.0	0.4	0.0
Stone Clay & Glass	0.3	0.0	0.4	-0.1
Printing and Publishing	0.3	0.0	0.3	0.0
Transportation and Warehousing	0.3	0.1	0.4	-0.3
Real Estate	0.2	-0.1	0.0	0.3
Amusements	0.2	0.0	0.2	0.0
Lumber and Wood Products	0.1	0.0	0.4	-0.3
Leather	0.1	0.0	0.5	-0.4
Mining	0.0	-0.2	0.7	-0.6
Finance and Insurance	-0.1	-0.3	0.5	-0.3
Wholesale and Retail Trade	-0.1	-0.1	0.2	-0.3
Primary Metals	-0.4	-0.1	0.3	-0.6
Pers. & Misc. Svcs.	-0.4	0.0	0.0	-0.4
Crude Pet. Mining & Ref.	-0.5	-0.1	0.1	-0.4
Construction	-0.6	0.0	-0.2	-0.4
Utilities	-0.6	-0.2	0.1	-0.4
Automotive Repair	-0.7	-0.2	-0.1	-0.3
Radio and TV	-1.2	-0.5	0.0	-0.8
U.S. Average	**0.2**	**0.0**	**0.3**	**0.0**

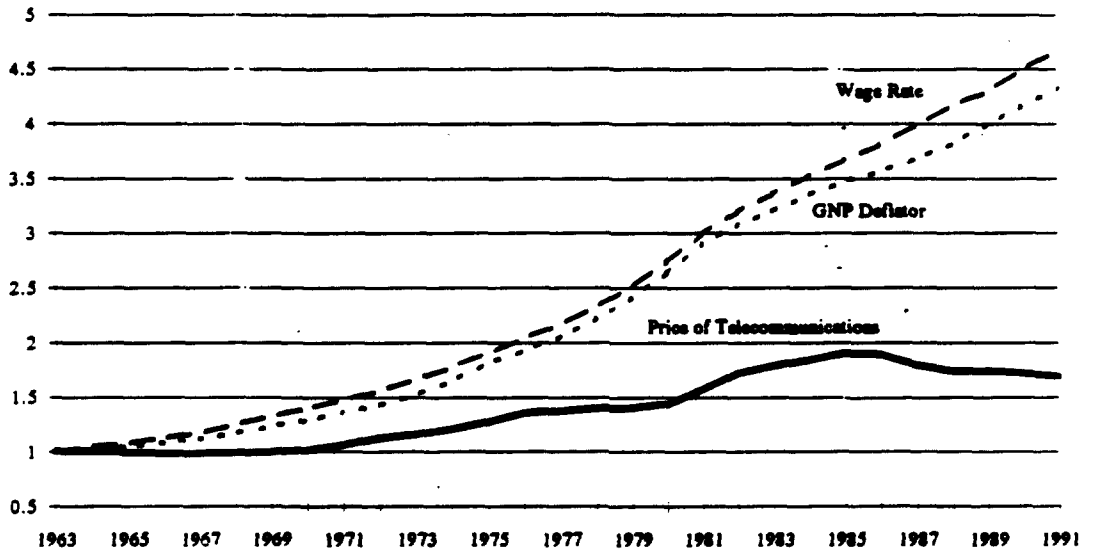
Source: DRI/McGraw-Hill. The Leontief Index is a measure of observed changes in production efficiency within each industry and for the entire economy from 1963 to 1991.

II-2. Telecommunications Infrastructure & Competitiveness

These productivity gains in combination with the fact that real telecommunications infrastructure investment grew at nearly twice the rate of real gross private investment and more than six times the rate of real public investment, enabled the telecommunications industry to substantially lower its price relative to the prices of other goods and services (*Exhibit II-2-1*). *Between 1963 and 1991, the price of telecommunications services fell 61% relative to the GNP price deflator and 64% relative to the average wage rate.* This substantial improvement in the relative price of telecommunications services had implications for both users of telecommunications services and for the economy, in general.

Exhibit II-2-1

Price of Telecommunications vs. Wage Rate and GNP Price Deflator (Index, 1963=1.0)



Source: The wage rate is defined as national wages/total employment. Wages are available from the National Income and Product Accounts, "National Product and Income", Table 1.14. Employment is available from the U.S. Department of Labor, Bureau of Labor Statistics. GNP Price deflator is available from the National Income and Product Accounts, "National Product and Income," Table 1.2. Price of Telecommunications is available from the FCC via the Bureau of Labor Statistics.

End-User Benefits

These changes not only revolutionized production processes in the industry itself, but affected the broader economy, particularly because telecommunications services are a vital and pervasive input in the production process of other sectors. Industries throughout the

U.S. economy responded to these price reductions by increasing their consumption of telecommunications relative to other inputs in their own production processes.

Input intensity measures the consumption of an input as a proportion of output. For example, increases in intensity of telecommunications usage by industries reflect a relative increase in telecommunications services as inputs to their production processes. The analysis of industry-specific telecommunications intensity provides insight into the importance of telecommunications to individual industries and to sectoral and economy-wide productivity. Whether an industry is telecommunications intensive or not, an observed high rate of intensity growth reveals that the industry has found better ways to produce its output by using relatively more cost-effective telecommunications. Changes in real intensity of use of inputs are determined by two factors: 1) changes in technology, reflecting changes in the ways inputs generate output and 2) changes in prices that induce substitutions of cheaper inputs.

In reviewing the level of intensity of usage for 30 sectors by the national economy, DRI has found that the proportionate industrial usage of telecommunications services has grown at a faster rate since 1965 than the use of any other input. *The economy as a whole increased its use of telecommunications as a percentage of output at a rate of 3.9% per year over the 1965-1987 interval.* Considering that the second highest sector in intensity growth from 1965 to 1987 was 28% lower than telecommunications, and less than half of all industries in the economy were more heavily used as inputs in 1987 than they were in 1965, telecommunications' growth of 3.9% is indeed substantial.

Table II-2-1 presents data on the level of telecommunications intensity for 30 industries. In 1987, the average industry used $0.62 worth of telecommunications services to produce $100.00 worth of output, compared with $0.27 to produce the same output in 1965. This table also shows that traditional service sectors are heavy users of telecommunications services: six of the top eight most telecommunications-intensive industries are service oriented. Finance and insurance, personal and miscellaneous services, and business services, wholesale and retail trade and transportation and warehousing are all well above the national average. Furthermore, it is significant as an indicator of the relative degree to which the national economy, in general, depends on telecommunications as an input that the top eight telecommunications-intensive sectors produced 45.3% of total U.S. output in 1987.

Table II-2-1

Telecommunications Consumption as a Percent of Consuming Industry Output
(Millions of 1991 $ of Purchased Telecommunications as a Percent of Total Output)

	1965 Telecommunications Intensity	1987 Telecommunications Intensity	1965-87 Average Annual Growth Rate	Intensity Growth Rank
Telecommunications	0.70	1.80	4.36	8
Finance and Insurance	0.81	1.55	2.97	15
Wholesale and Retail Trade	0.51	1.02	3.26	13
Business Services	0.75	0.99	1.26	26
Transportation and Warehsg	0.38	0.93	4.11	10
Fabricated Metals	0.23	0.90	6.29	4
Personal. & Misc. Services.	0.32	0.83	4.44	7
Electric & Electronic Equip.	0.42	0.83	3.12	14
Rubber & Plastics	0.22	0.78	6.01	5
Stone Clay & Glass	0.20	0.77	6.36	3
Printing and Publishing	0.43	0.73	2.48	17
Radio and TV	1.45	0.59	-4.03	30
Instruments	0.44	0.55	1.03	27
Amusements	0.29	0.54	2.92	16
Comp. Office & Non-Elec. Mach.	0.33	0.54	2.21	20
Primary Metals	0.13	0.46	5.82	6
Automotive Repair	0.20	0.33	2.33	19
Textiles	0.21	0.29	1.47	24
Mining	0.06	0.27	7.28	2
Furniture	0.24	0.27	0.49	29
Construction	0.11	0.26	4.14	9
Chemicals and Products	0.18	0.25	1.63	23
Paper and Paperboard	0.15	0.23	2.01	21
Lumber and Wood Products	0.10	0.23	3.78	12
Leather	0.16	0.22	1.38	25
Motor Vehicle. & Misc.	0.15	0.22	1.77	22
Real Estate	0.09	0.20	3.89	11
Agriculture. Food & Tobacco.	0.14	0.17	1.02	28
Crude Pet. Mining & Ref.	0.03	0.15	8.35	1
Utilities	0.07	0.12	2.37	18
U.S. Average	0.27	0.62	3.86	

Source: DRI/McGraw-Hill

It is particularly interesting to note that a substantial increase in the real substitution of telecommunications per unit of other inputs by the average industry occurred over the 1982-1991 time frame. The real rate of substitution averaged approximately 1.2:1 during the 1965-1982 interval, indicating that, over this interval, the average industry saved an additional 20 cents in real expenditures for other resources by substituting $1.00 of telecommunications. Over the decade 1976-1985, annual net investment in telecommunications increased by 130%. Research by DRI indicates that the U.S. economy requires almost five years to incorporate up to 50% of the benefits from telecommunications investment, and seven to nine years to realize 90% of the benefits.[10] *Given this substantial increase in investment in telecommunications over the 1976-1985 interval and the associated lag structure for the benefits to be fully realized by society, it is not surprising that the real rate of substitution rose by 25% between 1982 and 1991.*

The increase in the real substitution rate of telecommunications relative to other inputs is important because it reflects markedly improved efficiencies among end users in incorporating telecommunications into their production processes. Such an increase can be attributed to the convergence of such factors as: 1) the deregulation of consumer premise equipment in the early 1980s making more equipment options available to end users; 2) the partial deregulation of long distance services; 3) the advent and growth of new end-user technology such as personal computers and fax machines; and 4) basic network modernization as mentioned above. These factors led to significant and sizable improvements in the effectiveness of the production processes of end-user industries. This observation is supported by econometric tests conducted by DRI that confirmed a statistically significant relationship between total investment in telecommunications infrastructure and total factor productivity in the U.S.

Over 1982-91 the price of telecommunications services continued to decline relative to other inputs. This improvement in price can be seen in the increase in the nominal substitution ratio in telecommunications services for other inputs from 1.6:1 in 1982 to 2.3:1 by 1991. This means that in 1991, for every nominal dollar increase in telecommunications expenditures, $2.30 in other inputs were saved. The increase in the nominal substitution ratio over this interval was due to both the substantial increase in real rates of factor substitution described above and the continuing drop in the relative price of telecommunication services.

The benefits to end-users from telecommunications infrastructure investment, therefore, are embedded in the substitution by industries of telecommunications services for other inputs in their production processes. These benefits do not occur immediately, but, rather are fully incorporated by end-users over almost a decade. *Empirical evidence suggests that substantial impacts to end users can result from telecommunications infrastructure investment, albeit with the appropriate lag following the investment and the availability of new and advancing end user applications.*

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[10] DRI work in progress.

Implications for the Economy

Clearly, the advancement in the quality of telecommunications and the decline in real telecommunications prices contributed to a dramatic increase in the consumption of telecommunications services. From a societal viewpoint, however, the significance is the additional resources made available as telecommunications usage displaced less efficient and more costly resources. DRI estimates that the increased use of telecommunications in place of other inputs over the 1963-1991 interval saved the 1991 economy $42.8 billion in labor and capital consumption.

Therefore, as summarized in ***Table II-2-2***, *our analysis demonstrates that the combined impacts of improved production efficiencies by the telecommunications sector and increased telecommunications consumption by other sectors saved the 1991 economy* $102.9 billion in labor and capital. In other words, had these gains in telecommunications productivity not occurred, the economy would have had to use $102.9 billion more in primary inputs to achieve the level and composition of GDP actually produced in 1991. This $102.9 billion of capital and labor represents 8.0% of the increase in primary inputs required by the economy to support the growth in GDP which occurred between 1963 and 1991.

Table II-2-2

1991 Savings in Total Resources
Due to Improved Telecommunications since 1963
(Billions of 1991 Dollars)

Sources of Savings	Savings
Resources Saved in Telecommunications Production	$60.1
Resources Saved by Increasing the Efficiency of Other Industries	$42.8
Total Resources Saved Due to Improved Telecommunications	$102.9

Source: DRI/McGraw-Hill

These resource savings can be translated into identifiable and measurable effects that have pervasive impacts on all aspects of the economy. Specifically, the resource savings due to telecommunications investment have positively affected both economy-wide prices and international competitiveness and have provided society with a high rate of "social" return.

The productivity gains that have been attributed to advancements in telecommunications infrastructure from 1963 to 1982 have been reflected in the relative prices of other goods and services. *Previous analysis by DRI indicates that the Consumer Price Index (CPI) has declined by five percentage points as a result of the productive impacts induced by the telecommunications infrastructure investment.*[11] Considering the implications of the CPI's movement on vital components of the economy such as labor contracts, entitlement pay-

[11] Francis J. Cronin, M. Gold, and S. Lewitzky. "Telecommunications Technology, Sectoral Prices, and International Competitiveness." *Telecommunications Policy*, September/October 1992.

outs, the standard of living, and international competitiveness, it is an important yardstick to measure the significance of telecommunications infrastructure on general economic well-being.

The inflation-fighting property of telecommunications investment had a sizable impact on the U.S. trade position. For example, *between 1977 and 1982, DRI calculates that U.S. exports increased by over $50 billion as a result of increased competitiveness induced by telecommunications infrastructure improvements.*[12]

It is often useful when comparing alternative investment activities to develop one overall measure, capturing impacts across all dimensions of society. Recent research performed by DRI has quantified the return on telecommunications investment to society[13] using a rate-of-return approach that captures the social returns. *This analysis indicates that the constant dollar "social" rate of return associated with real new nation-wide telecommunications investment was 27% over the 1963 to 1982 period.* The nominal dollar social rate-of-return over this period was 32%.[14] This indicates a rate-of-return for society substantially in excess of the 10% rate employed by the Federal government's Office of Management and Budget as a benchmark for the selection of public projects.

Regulated rates of return for telephone companies are typically in the 12% to 15% range, indicating that there is a significant gap between the return to the company making the investment decision and the return to the society that stands to benefit from that decision. *This difference suggests that the total benefit to society from the investment activity in telecommunications far exceeds the returns to the firm or industry making the investment.*

Consistent with the social rate-of-return figures for domestic telecommunications investment calculated by DRI, are rates of return associated with recent telecommunications investment projects by the World Bank that ranged from 11% to 35%, averaging 18%.[15] Where it has been possible to calculate them, the economic rates of return have been found to be in the 17% to 50% range, averaging 27%.

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12 Ibid.

13 Private investment decisions are typically made on the basis of the expected return to the investor. However, if the investment under consideration is intended to enhance public infrastructure, the return on investment should be measured in terms of potential benefits to both the investor and the public. Predicting the investor's return to the exclusion of public benefits could greatly underestimate the true importance of the investment and lead to business decisions that may hinder economic growth at a national, state, or regional level.

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15 Saunders, page 13.

II-3. Telecommunications and Other Critical Public Policy Issues

The previous section discussed the critical role telecommunications has played in improving the nation's productivity growth rate, standard of living, competitiveness, and price level. This section will review the additional positive impact telecommunications has had on issues now at the top of the public policy agenda: the costs of providing health care and educational services. Indeed, as fiscal pressures on state and local budgets build, funds for critical services such as education and health care have become increasingly scarce.

Studies by DRI have shown that while the costs of modernizing the public switched network are not trivial, they are nonetheless relatively low when compared with the cost of providing other types of social services. For example, households in a typical large urban area on the East Coast in 1989-90 spent approximately $55 on library expenses. Such an expense is above most estimates of modernization costs.

Moreover, telecommunications may have the ability to improve information dissemination by providing service more widely, as well as increasing the volume of information available. Indeed, access to the entire Library of Congress may be feasible. This consideration is particularly important in areas that are typically information poor, such as rural communities.

> *"In the absence of an accessible and reliable telecommunication service such [information processing] activities suffer a variety of inefficiencies, including the creation of markets in which a few information-rich individuals are able to gain significant advantage over the majority of those who are information poor."*[16] *[Saunders]*

Analysis conducted by DRI also shows that direct health care costs would have been measurably higher in every year from 1963 through today, had the technology of telecommunications service provision not advanced from methods in 1963. *Annual savings in health care expenses due to telecommunications advances since 1963 have reached or exceeded 0.8% of total costs since 1980 and have reached or exceeded 1% of total costs since 1988.* Moreover, there is reason to believe that the full potential of telecommunications as a substitute for more expensive inputs and processes has not yet been realized. *Potential applications of existing telecommunications technology could save the U.S. economy $24 billion (current dollars) in 1995 and $38 billion by the year 2000.*

In addition to health care costs, both public and private education costs would have been measurably higher in every year from 1963 through today, had the technology of telecommunications service provision not advanced from methods in 1963. Annual education costs in 1991 would have been $8.4 billion higher had the technology of telecommunications service provision not advanced since 1963.

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16 Robert J. Saunders, Jeremy J. Warford, and Bjorn Wellenius, *Telecommunications and Economic Development*, John Hopkins University Press, Baltimore, Maryland, 1983, page 15.

II-4. Findings and Observations

The historical private infrastructure investment pursued by the telecommunications sector has resulted in identifiable and measurable impacts on the national economy. Specifically, network modernization increased telecommunications production efficiencies, lowered telecommunications service prices, increased end-user productivity and positively impacted inflation and the U.S. trade deficit. This implies that without advances in telecommunications production, the U.S. economy would have experienced greater declines in productivity during the 1970s and a slower recovery in the 1980s. Key findings include:

- From 1889 to 1988, the rate of total factor productivity growth in the U.S. averaged 1.6% per year. Since the early 1960s, the growth of productivity for the U.S. economy has fallen below our historical performance and the contemporaneous performance of other industrialized nations.

- Public infrastructure investment experienced virtually no real growth over the 1963-1991 period. Telecommunications and gross private investment, however, showed significant real growth.

- The telecommunications industry increased the productivity of its production process by an average of 3.0% per year between 1963 and 1991, faster than any other sector of the economy.

- Between 1963 and 1991, the price of telecommunications services fell 61% relative to the GNP price deflator and 64% relative to the average wage rate.

- The U.S. economy as a whole increased its usage of telecommunications as a percentage of output at an annual rate of 3.9% over the 1965-1987 interval.

- The combined impacts of improved production efficiencies by the telecommunications sector and increased telecommunications consumption by other sectors saved the 1991 U.S. economy $102.9 billion in labor and capital.

- The resource savings due to telecommunications investment have positively affected both economy-wide prices and international competitiveness and provided society with a high rate of "social" return.

- Advancements in telecommunications technology since 1963 have contributed to savings in health care and education expenses. Potential applications of existing telecommunications technology could save the U.S. economy $24 billion (current dollars) in 1995 and $38 billion by the year 2000 in health care expenses; annual education costs in 1991 would have been $8.4 billion higher had the technology of telecommunications service provision not advanced since 1963.

III. HISTORICAL IMPACT OF TELECOMMUNICATIONS INFRASTRUCTURE ON THE ARKANSAS ECONOMY

Introduction

This section describes the historical relationship between telecommunications infrastructure modernization and the overall economic performance of the state of Arkansas. Economic performance is measured using tax revenues, employment, prices, and income. Telecommunications infrastructure includes local exchange carriers, long-distance providers, and other communications carriers, as well as private networks. The figures reported here are defined as the difference between the actual 1977 through 1991 levels of employment, income, and tax revenues in Arkansas and those that would have been generated during this period if the telecommunications infrastructure had not been modernized since 1977.

Overview

The ability of industries in Arkansas to translate enhanced telecommunications production and consumption into greater cost-competitiveness has affected the state's employment, income and tax revenues. Our research shows that advances in telecommunications technology since 1977 have allowed industries to lower production costs. With the oversight of regulators, and by producing telecommunications services more efficiently since 1977, the telecommunications industry has been able to lower its prices relative to other prices as reflected in the overall price level (see **Section II** for further discussion). Thus, industries pay less to produce their output because modern telecommunications production technology enables firms to purchase their telecommunications needs more cheaply. Furthermore, new and enhanced telecommunications services have enabled industries to expand their use of telecommunications relative to their use of other, more costly inputs, such as transportation, lodging, and delivery services. This trend has also contributed to significant per-unit cost savings in the production process.

DRI has quantified the relationship between each industry's increase in telecommunications consumption and its corresponding cost savings per-unit output, using the Telecommunications Input Substitution Model (see **Section VII** for a further discussion). This model represents a state-of-the-art system of industry-specific econometric equations that expresses an industry's production function, and explains how input choices change in response to external factors such as technology, shifting input prices, and economies of scale. DRI uses this model to calculate each industry's "telecommunications substitution ratio," the amount of alternative inputs that an industry can eliminate from its production process while maintaining output constant when it increases its use of telecommunications. By applying each industry's substitution ratio to the Arkansas economy, DRI is able to determine the degree to which each Arkansas industry has translated increased telecommunications consumption into lower unit costs since 1977.

These direct industry cost savings have additional impacts on downstream industries. In the competitive marketplace, lower input costs are generally translated into lower output prices. DRI estimates indirect cost savings using the Interindustry Model (see Section VII for a further discussion). This model is an accounting system of all sales and purchases between industries and from industries to final consumers that take place as each industry in the economy produces enough goods or services to satisfy its demand. For example, the model keeps a record of the amount of energy the steel industry must purchase to produce a sufficient amount of steel to meet demand. When telecommunications-induced efficiencies cause energy prices to fall, DRI analysts use the information in the Interindustry Model to calculate the specific percentage by which steel producers' input costs decline when the price of energy drops by a specific percentage. But the model also keeps a record of the amount of steel that the automobile industry must purchase in order to meet demand for cars. We then use this information to calculate the specific percentage by which car makers' input costs decline when steel prices drop by a certain amount. Thus, using this model, we can estimate the total direct and indirect cost savings throughout the entire Arkansas economy due to advanced telecommunications technology. DRI finds that once all of these cost-saving factors are simultaneously taken into account, the average Arkansas industry in 1991 produced its output at 1.2% lower cost than it would had telecommunications technology not advanced since 1977. A listing of cost savings experienced by each Arkansas industry as a result of an enhanced telecommunications infrastructure is presented in ***Table III-1-1.***

The cost savings helped to lessen the cost of doing business in Arkansas, and to retard business out-migration over the past decade. Consumers also shifted some of their consumption from out-of-state products to Arkansas products. More importantly, many consumers made purchases they would not have been willing to make at all in a less cost-competitive environment. These sources of demand combined to spur economic activity in Arkansas, which boosted employment and real wages, generating greater spending power. New spending then spurred further economic activity, leading to further gains in employment and real wages, and so on, until upward pressure on wages began to slow economic growth until it was brought back into balance. Had Arkansas maintained the telecommunications usage of 1977, these benefits would not have occurred.

DRI has quantified the relationship between lower production costs and overall economic expansion using the Arkansas State Model (see Section VII for a further discussion). This model is a system of 150 econometric equations that link a wide variety of concepts, including employment, wages, income, state and local taxes, housing, and consumer prices. We use it to estimate the extent to which a decrease in input costs and consumer prices leads to a rise in demand, and the extent to which this higher level of demand, in turn, generates higher output, employment, real wages, income, and spending, among other factors. Finally, we use the Arkansas State Model to estimate how soon and to what degree increasing pressure from wage growth slows economic expansion. This final piece is important as the higher wages resulting from the effects of economic growth on the labor supply can ultimately undermine economic expansion. This, in fact, was the case in the

late 1980s in Massachusetts when a tight labor supply put upward pressure on wages and helped to end the "Massachusetts' miracle".

DRI finds that when all of these economic factors are taken into account, telecommunications modernization in Arkansas has generated an average of 4,800 jobs per year since 1977, exceeding 10,800 jobs in 1991. Moreover, these productivity enhancements generated a cumulative total of $3.7 billion in real personal income between 1977 and 1991 (an average of over $260 million per year, with nearly $570 million in 1991) and almost $332 million in state and local tax revenue between 1977 and 1991 (an average of $24 million per year, up to almost $52 million in 1991). (These and all other dollars figures in this section are expressed in 1991 dollars unless otherwise noted.)

These increases in income and tax revenue are greatly enhanced by the fact that, because of the 1.4% reduction in the CPI in 1991 resulting from telecommunications-induced efficiency gains, a dollar bought more goods and services in Arkansas in 1991 than it could have without post-1977 increase in telecommunications usage. The real income and tax figures reported above represent the increase in purchasing power associated with telecommunications advancements. For example, in 1991, personal income was higher by $89 million in nominal terms, but, because telecommunications also helped lower prices, this increase in income was associated with an increase in purchasing power equivalent to nearly $570 million. Similarly, a nominal increase of $8.1 million in state and local tax revenue in 1991 translates into a purchasing power increase equivalent to nearly $52 million. These findings have important implications for the average household, as discussed in the **Telecommunications-Induced Efficiency Gains** section below.

The physical process of designing, constructing, and maintaining the enhanced infrastructure also supported employment and income in Arkansas. The resulting increases in demand for materials and services to support the construction activity supported additional jobs and income, and the resulting increase in consumer spending sparked still more economic activity. DRI estimates that designing, building, and maintaining a modern telecommunications infrastructure directly or indirectly supported an average of 3,700 jobs per year between 1977 and 1991.

We assume that since this construction-related effect on economic activity was unrelated to efficiency gains, it would not cause the Arkansas CPI to change substantially. Thus, the inflation-adjusted and unadjusted measurements yield the same result. DRI finds that the economic activity stemming from network design, construction, and maintenance supported $74 million in 1991 state-wide personal income. Between 1977 and 1991 this process supported an average of $86 million per year. Network design, construction, and maintenance also supported an average of almost $7.5 million per year in state and local tax revenues. These results are summarized in the section titled, **Network Design, Construction, and Maintenance Related Gains** below.

Many of the benefits associated with telecommunications usage and price declines since 1977 have not yet been fully experienced. Unlike many jobs programs, the importance to

the economy of modernizing telecommunications technology lies not in the initial jobs associated with designing and building the network, but in the long-term efficiency gains made possible throughout all segments of the economy. Once these gains are incorporated into the production process, they remain in place, and are often enhanced as firms continue to discover new applications.

III-1. Industry Cost Savings

Advances in telecommunications technology induce production cost savings in all industries. Our analysis shows that Arkansas's industries have steadily reduced input costs as a result of improved telecommunications technology and increased consumption of telecommunications services since 1977. The ability of the Arkansas economy to translate telecommunications into cost savings is a function of four factors: 1) the intensity with which industries consume telecommunications to produce their output, 2) the rate at which industries *increase* their consumption of telecommunications services, 3) the rate at which industries substitute telecommunications services for more costly alternative inputs, and 4) the state's industry mix.

Table III-1-1 displays the 1991 percent savings in production costs achieved by each individual Arkansas industry as a result of infrastructure modernization since 1977. For example, the real estate industry was able to translate its increased telecommunications consumption into a 3.1% lower per-unit production cost. Excluding the telecommunications sector itself, the top five industries saw per-unit costs decline an average of about 1.7%. Telecommunications providers saw their per-unit costs decline by 37.1%.

Table III-1-1

1991 Production Costs Saved Due to Telecommunications Advances Since 1977

Industry	Total Percent Savings due to Telecommunications
Real Estate	3.1%
Finance and Insurance	2.5
Fabricated Metals	1.5
Trans. and Warehousing	1.2
Automotive Repair	1.0
Lumber and Wood Prod.	0.9
Personal Services	0.9
Primary Metals	0.9
Business Services	0.8
Wholesale and Retail Trade	0.8
Computers & Mach	0.8
Agriculture	0.7
Elec. and Electron. Equipment.	0.8
Petroleum Refining	0.8
Tobacco	0.8
Food	0.7
Miscellaneous Services	0.7
Printing and Publishing	0.7
Instruments	0.6
Paper and Paperboard	0.6
Construction	0.6
Chemicals and Products	0.6
Crude Petroleum Mining	0.5
Mining	0.5
Motor Vehicles and Equipment.	0.5
Misc. Manufacturing	0.5
Furniture	0.5
Leather	0.5
Radio and TV	0.5
Utilities	0.4
Amusements	0.4
Other transportation Equip.	0.3
Stone Clay & Glass	0.3
Rubber & Plastics	0.2
Textiles	-0.3
Telecommunications	*37.1*
Arkansas Economy	*1.2*

Source: DRI/McGraw-Hill

As explained above, these cost savings are a function of telecommunications-intensity, substitutability, and industry mix. On an industry-specific basis, however, there is another